(12) UK Patent Application (19) GB (11) 2 233 803 (13) A

(43) Date of A publication 16.01.1991

(21) Application No 9011832.4

(22) Date of filing 25.05.1990

(30) Priority data
(31) 8912945 (32) 06.06.1989 (33) GB

(71) Applicant
The De La Rue Company Plc
(Incorporated in the United Kingdom)
3/5 Burlington Gardens, London, W1A 1DL, United Kingdom

(72) Inventor
Peter Baston

(74) Agent and/or Address for Service
Gill Jennings & Every
53-64 Chancery Lane, London, WC2A 1HN, United Kingdom

(51) INT CL⁵
G08B 23/00 29/08

(52) UK CL (Edition K)
G4N NAT1 NCSE

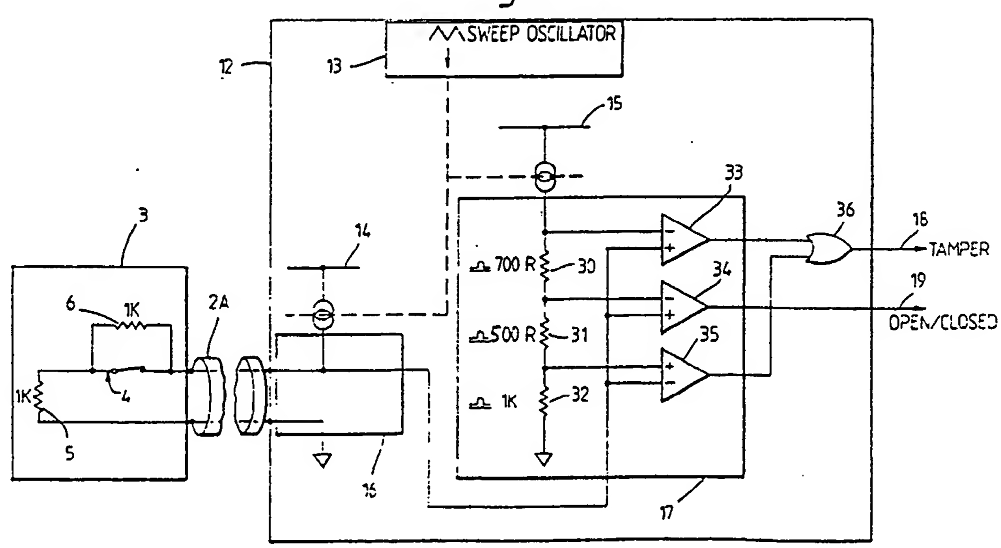
(56) Documents cited
None

(58) Field of search
UK CL (Edition J) G4N NATX NAT1 NCSE
INT CL⁴ G08B

(54) **Electronic condition sensing system**

(57) In the electronic sensing system control means 12 are coupled via two wires 1, 2 to a sensing device 3 forming an electrical loop, the performance of which is altered by the sensing device sensing a particular condition. A current supplied to the loop is repeatedly modulated, using amplitude and frequency or phase variation one of which is non regular. An alarm condition occurs if one or more characteristics of the modification differ from the original. Apparatus operating this method has particular use in integrated security systems for large sites.

Fig.2.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy

Fig.1.

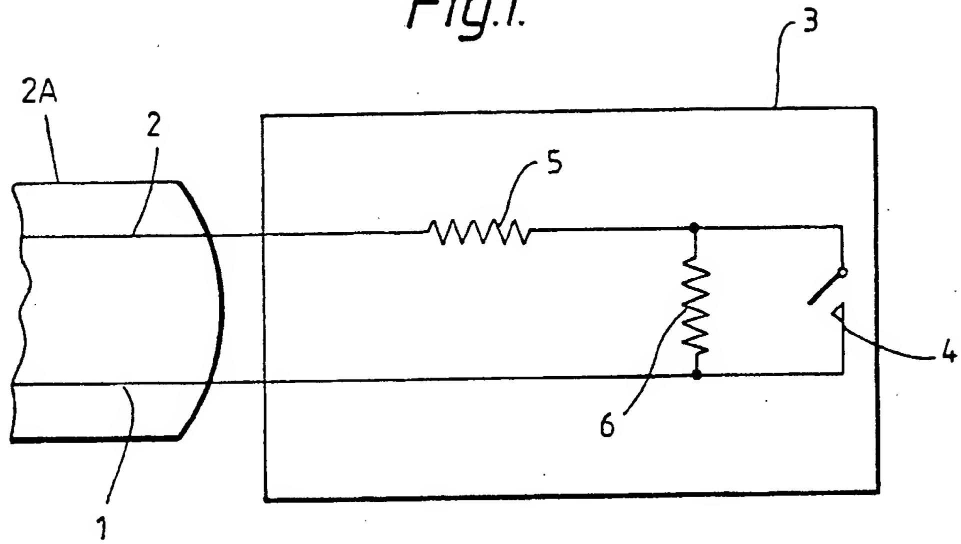
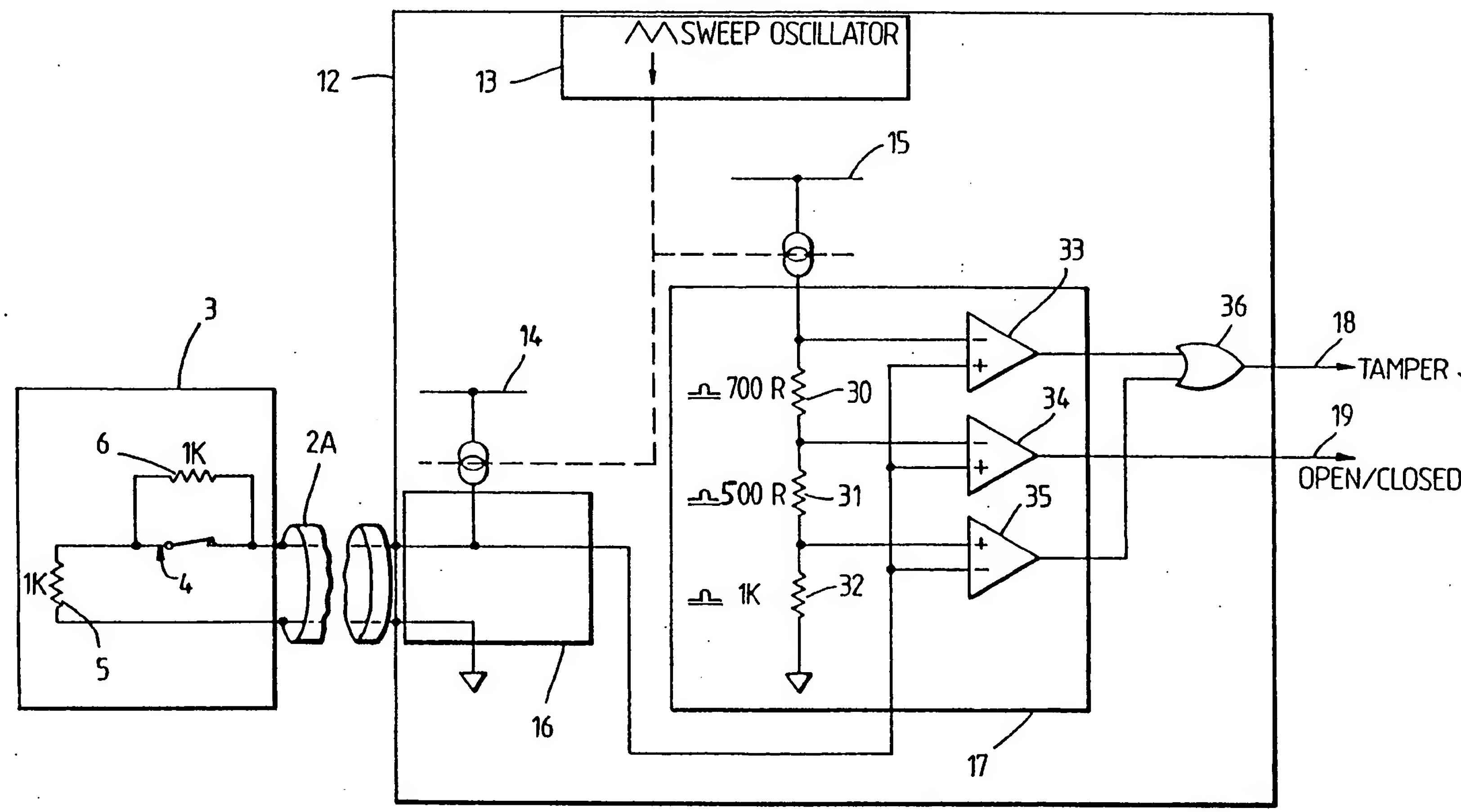
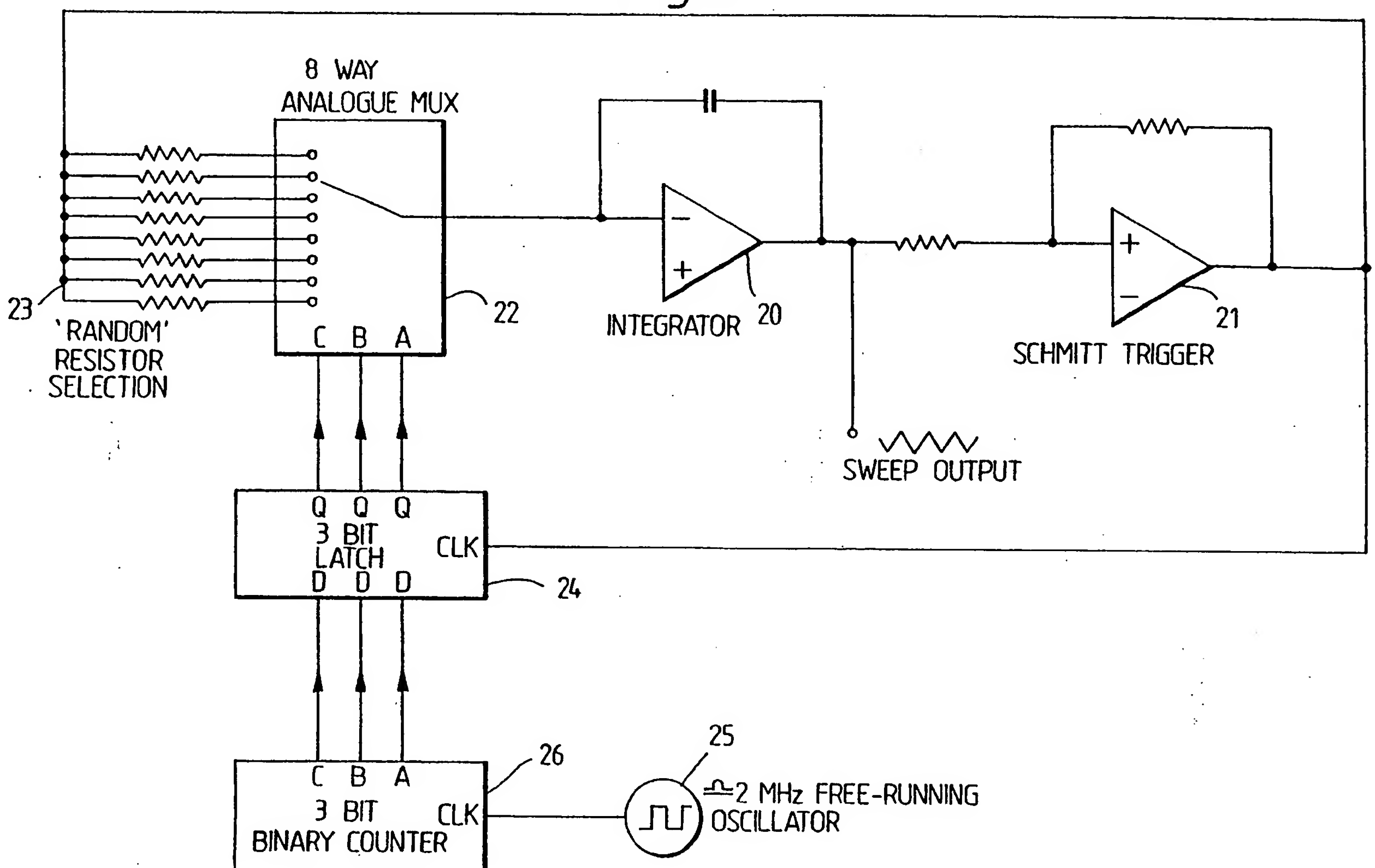


Fig.2.



SWEEP OSCILLATOR
12
13
14
15
16
17
18
TAMPER
19
OPEN/CLOSED
3
6
1K
4
1K
5
2A
700 R
30
500 R
31
1K
32
33
34
35
36

Fig.3.


8 WAY
ANALOGUE MUX
22
C B A
23
'RANDOM'
RESISTOR
SELECTION
INTEGRATOR
20
SCHMITT TRIGGER
21
SWEEP OUTPUT
Q Q Q
3 BIT
LATCH
CLK
D D D
24
C B A
3 BIT
BINARY COUNTER
CLK
26
25
2 MHz FREE-RUNNING
OSCILLATOR

4/5

Fig.4.

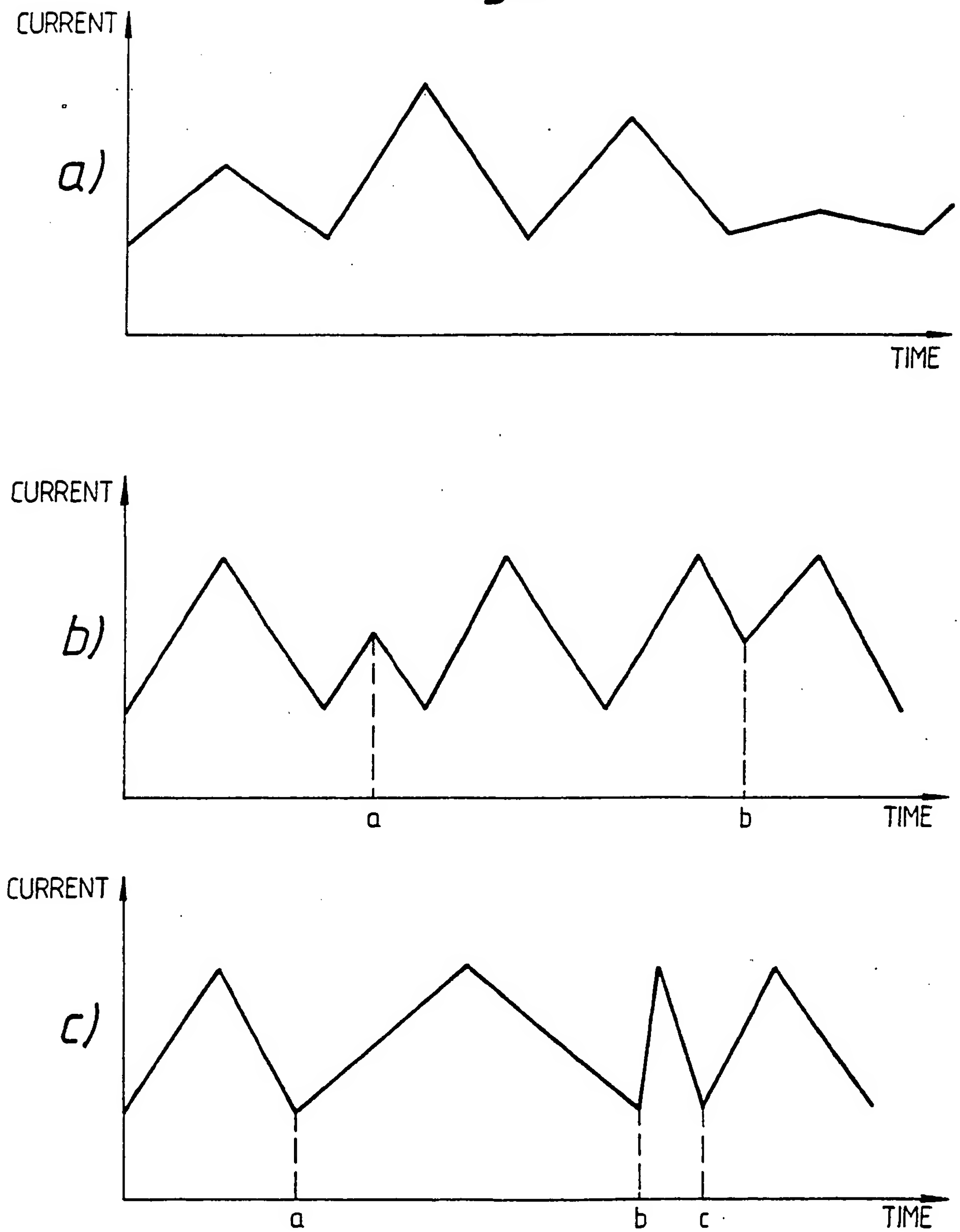
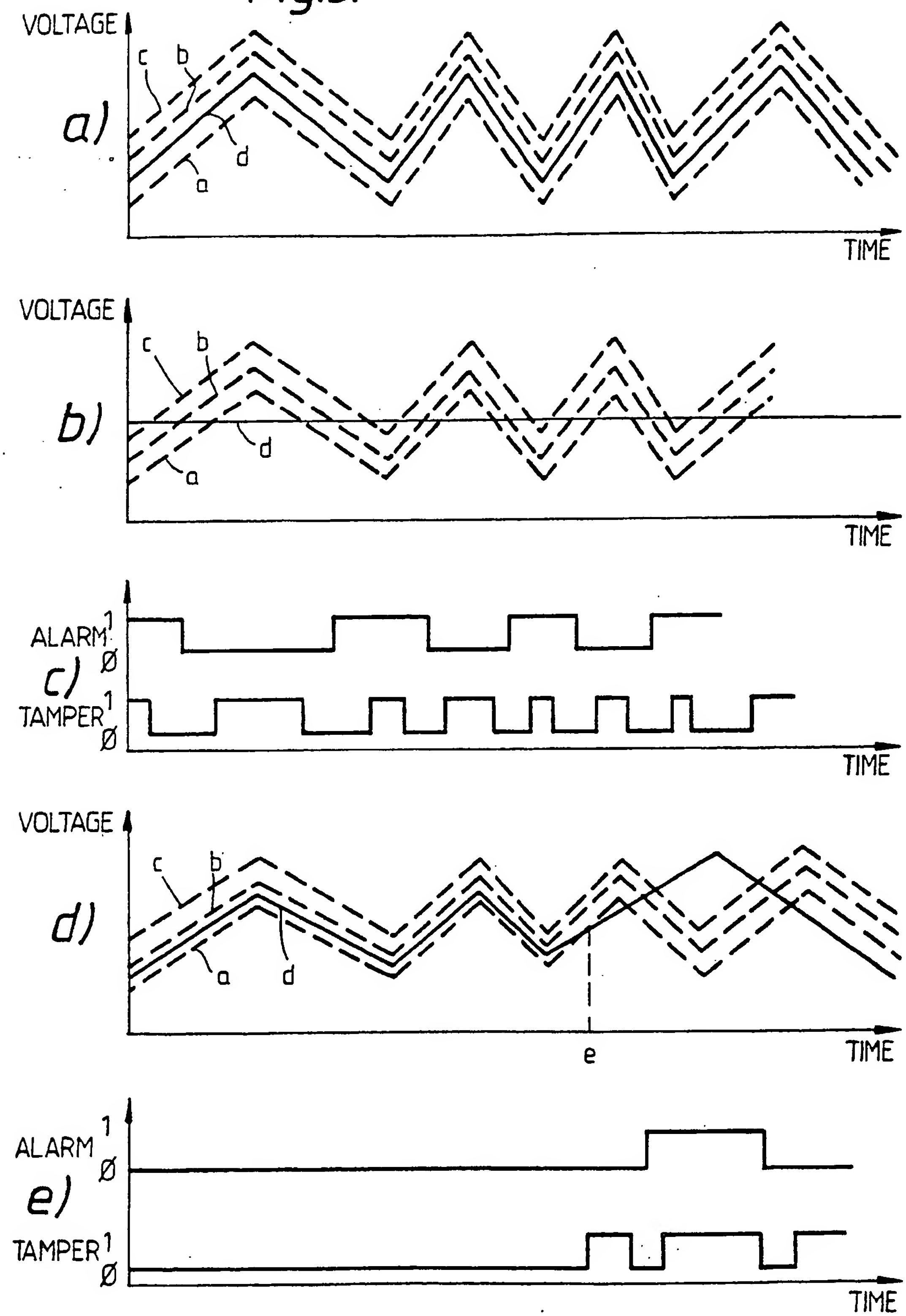


Fig.5. 5/5


VOLTAGE
c
b
a)
d
a
TIME
VOLTAGE
c
b
b)
d
a
TIME
ALARM 1
Ø
c)
TAMPER 1
Ø
TIME
VOLTAGE
c
b
d)
a
d
e
TIME
ALARM 1
Ø
e)
TAMPER 1
Ø
TIME

2233803

Electronic Sensing System

The invention relates to a supervised electronic sensing system and a method of operating such a system of the kind comprising a condition sensing device, and control means coupled by two wires with the sensing device to form an electrical loop, the sensing device changing the electrical performance of the loop upon sensing the said condition, wherein the control means controls the current flowing in the loop and monitors the voltage across the loop to detect a change in the electrical performance of the loop. Such electronic sensing systems are hereinafter referred to as of the kind described.

In one example of an electronic sensing system of the kind described, the sensing device includes a variable resistance whose value is changed in accordance with whether or not the condition is sensed. In a conventional electronic sensing system, the control means supplies a substantially constant current to the loop which enables a change in resistance readily to be sensed. However, such systems can be bypassed by measuring the voltage across the loop with a high impedance volt meter and then connecting a low impedance voltage source set to the recorded voltage across the loop. This is a particular problem with alarm condition sensing devices which may then be disconnected without an alarm condition being indicated.

EP-0026461-B1 describes an alarm detector circuit which determines the resistance of a line by monitoring the current applied by a constant voltage source. The current is compared with predetermined limiting values in a comparator to produce an appropriate output signal.

US-A-3278903 describes a line supervisory circuit having a pair of wires to which an audio signal is applied and a remote station which returns a voltage signal via a separate pair of wires, the phase of the returned signal being monitored for variation.

In accordance with one aspect of the present invention, a method of operating an electronic sensing system of the kind described is characterised by repeatedly modulating the current supplied to the loop in a controlled manner, the modulation comprising an amplitude variation and a superimposed frequency and/or phase variation, at least one of the variations being non-regular and determining an alarm condition if the modulation of the voltage monitored by the control means differs from the original modulation.

In accordance with a second aspect of the present invention, an electronic sensing system of the kind described is characterised in that the control means repeatedly modulates the current supplied to the loop in a controlled manner in use, the modulation comprising an amplitude variation and a superimposed frequency and/or phase variation, at least one of the variations being non-regular; and in that the control means determines an alarm condition if the modulation of the said one or more characteristics of the current monitored by the control means differs from the original modulation.

In order to solve the problem of fraudulent tampering with the electronic loop, the invention imparts a known modulation having at least one non-regular variation onto the current supplied to the loop which makes it far more difficult for the loop to be tampered with. Typically the non-regular variation occurs at a very low frequency relative to the other variation.

In the preferred examples, the amplitude of the current is varied in a regular manner while the frequency

is varied in a random manner. This random variation could even be achieved on a cycle by cycle basis. In a preferred arrangement, the frequency of the amplitude variation is varied in a triangular wave manner.

Preferably, the control means includes a pair of current sources, one of which is connected to the two wires and the other of which is connected to a detection circuit, each of the current sources being modulated by a common modulator. In this way, the detection circuit can compensate for the known modulation applied to the current in the two wire loop.

In other arrangements, parts of the two wire loop and detection circuit could be modulated, for example, by switching in and out similar resistances, while the constant current sources are not modulated.

Integrated scanning and data acquisition systems are manufactured by Remsdaq Ltd. (JUPITER Brand). This system includes alarm handling capability through remote terminal units. STAR WATCH Brand integrated security systems which incorporate sophisticated computerised security monitoring, alarm handling and control systems are also manufactured by Remsdaq Ltd.

Protected zones are monitored and controlled by a security control panel. These may be remotely sited from the control room and are linked by telemetry, optical data or telecommunication systems. The security control panels are "intelligent" and provide continual "supervised" monitoring of the sensors and local alerting of incidents. In these as in any similar system the links between the condition sensors and the remote terminal units or local security control panels are vulnerable to attack. The invention has found particular use with these systems.

An example of an electronic sensing system and a method of its operation in accordance with the present

invention will now be described with reference to the accompanying drawings, in which:-

Figure 1 illustrates the remote end of the system;

Figure 2 is a block circuit diagram of the system; and,

Figure 3 is a block circuit diagram of a modulating device.

Figure 4 shows examples of random modulations which may be applied to the loop current.

Figure 5 shows examples of the operation of the invention under various operating conditions

Figure 1 illustrates a sensing device 3 which is coupled with a control unit (not shown in Figure 1) via two wires 1, 2 contained within a cable 2A. The sensing device 3 comprises a pair of resistances 5, 6 connected in series with the wires 1, 2 and a switch 4 connected in parallel with the resistor 6. The sensing device 3 is of a conventional form and upon sensing a certain condition, such as an alarm condition, the switch 4 is moved from its normal position, for example the open position shown in Figure 1, to its other position (closed) to change the affective resistance within the loop formed by the wires 1, 2 and resistances 5, 6. In this case, normally a resistance of 2R will be present in the loop but if the switch 4 is closed then the resistance changes to R and this change can be detected.

The full sensing system is shown in Figure 2 where the sensing device 3 is shown connected via the cable 2A with a control unit 12. The control unit 12 includes a current modulator formed by a triangular wave sweep oscillator 13 which varies the amplitude at a controlled frequency of the constant current applied from a pair of constant current sources 14, 15 to the cable 2A and a reference resistor and comparison unit 17 respectively. Outputs 18, 19 from the unit 12 provide loop tamper

condition and sensing device condition signals respectively which are fed to further processing apparatus (not shown).

The two sets of parameters to be measured relate to the status of the sensor itself and to a tamper condition. The sensor has a digital i.e. on-off, status and may also be arranged to allow an analogue signal to be passed.

The input signals from the sensor are hard wired to the remote terminal unit and these signals can be optoisolated from the terminal unit electrical circuitry which outputs status and tamper conditions independently.

The current source 14 is coupled with the cable 2A via a conventional loop connection circuit 16.

The reference circuit 17 comprises a resistor chain having three resistors 30 - 32 connected in series. The values of these resistances are shown in Figure 2. The resistor chain is coupled with the current source 15. Three comparators 33 - 35 are also provided. The inverting input of comparator 33 is coupled to a point between the resistor 30 and the current source 15; the inverting input of the comparator 34 is connected to a point between the resistors 30 and 31; and the non-inverting input of the comparator 35 is connected to a point between the resistors 31 and 32. The remaining inputs of the comparators 33 - 35 are all connected to one of the wires of the two wire loop via the connector 16.

Assuming that the loop has not been tampered with then the variation in voltage across the resistive chain will exactly follow the current applied to the loop and this is monitored by the comparator 33-35 which determines the resistance of the loop. Normally, the switch 4 is closed so that the resistance in the two wire loop will be a little greater than 1Kohm. If an alarm

condition is sensed by the sensing device 3 then the switch 4 opens and the resistance 6 will have effect leading to a resistance in the loop of a little greater than 2Kohm.

First, consider the case where no tampering takes place but the sensing device 3 causes the switch 4 to open. In its normal position, as shown in Figure 2, the resistance in the loop will be a little greater than 1Kohm in which case none of the outputs from the comparators 33 - 35 will be active or high. However, when the switch 4 is opened then the resistance in the loop will exceed by a small amount 2Kohm (but will be less than 2.2Kohm which is the total resistance in the chain) and so the output from the comparator 34 will change to high indicating a change in condition in the line 19.

The comparators 33, 35 are used to indicate a tamper condition if the current sources 14, 15 are not modulated. For example, if the loop resistance falls to below 1K then the output from the comparator 35 will be active while if the resistance increases above 2.2K then the output from the comparator 33 will be active. The outputs from the comparator 33, 35 are fed to an OR gate 36 so as to provide an active or high output from the line 18 if either of the comparators 33, 35 detects the tamper condition.

As has previously been explained, it may be possible in some circumstances for this change in resistance indicative of a tamper condition to be avoided. To deal with this, the current supplied by the sources 14, 15 is swept between a pair of preset, non-zero amplitude levels by the oscillator 13. In addition a further non-regular variation, for example in the frequency or phase of the current is imparted. Thus, if an attempt is made to insert an additional source across the loop, it will be

very difficult to arrange for this source to exactly mimic the particular type of sweeping current provided by the oscillator 13. This means that there will be a variation in phase between the amplitude of the two currents received by the comparators 33 - 35 which will indicate tamper and open conditions on the lines 18, 19 respectively at random intervals thus indicating that the integrity of the loop has been breached.

Figure 3 illustrates apparatus for causing the frequency of the swept current to vary in a random manner. For example, this apparatus can cause the frequency to change on a cycle by cycle basis so that any one cycle has a frequency between 4.5 and 2Hz. In the Figure 3 circuit, a triangular wave oscillator is formed by an integrator 20 and a Schmitt trigger 21 with any one of eight different integrator time constants being selectable by an analogue multiplexer 22 which causes the current to pass through any one of eight resistances 23. The particular resistor 23 is selected in each cycle from a choice of the eight options by causing a clock formed by an oscillator 25 to select at the end of each cycle of the current sweep an instantaneous value in a latch 24 which receives successive binary values from a binary counter 26. This causes one of the resistances and hence one of the integrator time constants to be held until the end of the next cycle. The counter 25 typically runs at about 2MHz through a conventional resistance-capacitance timing supply network.

Figures 4a, 4b and 4c show examples of random modulations which may be applied to the loop current. In all cases a triangular wave is used, as in the preferred example. Figure 4a shows an example of random amplitude modulation. In this example the applied frequency is constant and the amplitude of the wave is varied randomly on a cycle - by cycle basis. Figure 4b shows an example

of random phase modulation, again with a constant frequency. At times 'a' and 'b' the wavefrom undergoes a phase change and re-starts from a different part of the cycle. This type of modulation could be achieved, for example, either by changing the phase by a random amount at regular times or by re-starting the cycle at random times. Figure 4c is the modulation used in the preferred example. In this case the frequency varies randomly on a cycle-by-cycle basis. At times 'a', 'b' and 'c' a new time-constant is selected for the next cycle at random.

Figures 5a-5e show examples of the operation of the invention under various operating conditions. Figure 5a shows the operation of the invention under normal circumstances and with the sensor in the closed condition. Waveforms 'a', 'b', 'c' show the threshold voltages at the comparator inputs (the top of the resistors 32, 31 and 30 in Figure 2) and waveform 'd'shows the voltage across the loop. As can be seen the loop voltage is always above the lower tamper threshold ('a') and below the alarm threshold ('b') and the upper tamper threshold ('c'). This means that the comparator alarm and tamper outputs are always inactive.

Figure 5b shows the comparator inputs when a constant D.C. voltage is forced into the line. Again waveforms 'a', 'b', 'c' are the comparator threshold voltages, 'd' is the loop voltage. Figure 5c shows the resultant alarm and tamper outputs. As can be seen a tamper is generated when the loop voltage is outside the band formed by 'a' and 'c', an alarm is generated when the loop voltage exceeds threshold 'b'. From these diagrams it may be seen that there is no D.C. voltage which may be applied which will not produce a tamper and/or alarm state.

Figure 5d shows a more sophisticated attack in which an attempt has been made to track the random current.

The applied voltage tracks successfully up to time 'e' when the lower tamper threshold is crossed. Figure 5e shows the resultant tamper and alarm outputs. In practice, due to the random current variation, it would be very difficult to track the current for even this short time.

The circuitry is in the form of a circuit card and is designed to be used in fully supervised circuits. The interface card can be used for example with a remote terminal EUROPA system or LEDA system such as supplied by Remsdaq.

Up to sixteen inputs can be taken into the termination card from various sensors in the plant. The termination card has two outputs for each sensor (sensing condition and tamper condition). The EUROPA module is then connected (by landline, telemetry or optical fibre link) to the master control room computer.

CLAIMS

1. A method of operating an electronic sensing system comprising a condition sensing device, and control means coupled by two wires with the sensing device to form an electrical loop, the sensing device changing the electrical performance of the loop upon sensing the said condition, wherein the control means controls the current flowing in the loop and monitors the voltage across the loop to detect a change in the electrical performance of the loop is characterised by repeatedly modulating the current supplied to the loop in a controlled manner, the modulation comprising an amplitude variation and a superimposed frequency and/or phase variation, at least one of the variations being non-regular and determining an alarm condition if the modulation of the voltage monitored by the control means differs from the original modulation.

2. A method according to claim 1, wherein the frequency and/or phase of the current is modulated in a pseudo-random manner.

3. A method according to claim 1 or claim 2 wherein the frequency is varied every cycle.

4. An electronic sensing system comprising a condition sensing device, and control means coupled by two wires with the sensing device to form an electrical loop, the sensing device changing the electrical performance of the loop upon sensing the said condition, wherein the control means supplies a current to the loop in use and monitors the current flowing in the loop to detect a change in the electrical performance of the loop is characterised in that the control means repeatedly modulates the current supplied to the loop in a controlled manner in use, the modulation comprising an amplitude variation and a superimposed frequency and/or phase variation, at least one of the variations being non-regular; and in that the

control means determines an alarm condition if the modulation of the said one or more characteristics of the current monitored by the control means differs from the original modulation.

5. A system according to claim 3, wherein the control means includes a pair of current sources, one of which is connected to the two wires and the other of which is connected to a detection circuit, each of the current sources being modulated by a common modulator.

6. An integrated security system comprising an electronic sensing system according to claim 4 or claim 5.